What is claimed is:

1. An illumination system for illuminating a surface over an arcuate illumination field, comprising:

a) a light source for providing a light beam;

b) optical integrator system capable of forming from said light beam a plurality of arcuate light beams capable of forming a plurality of light source images.

2. An illumination system according to claim 1, further comprising a condenser optical system designed so as to condense said plurality of arcuate light beams to illuminate the surface over the arcuate illumination field in an overlapping manner.

3. An illumination system according to claim 2, wherein said condenser optical system comprises a condenser mirror with a focal point, said condenser mirror arranged such that said focal point substantially coincides with the surface.

4. An illumination system according to claim 2, wherein said condenser optical system comprises a condenser mirror having an aspherical surface.

5. An illumination system according to claim 2, wherein said optical integrator system comprises a plurality of reflecting elements each having a focal length f_F , said condenser optical system has a focal length f_C, and wherein the condition

$$0.01 < |f_F/f_C| < 0.5$$

is satisfied.

6. An optical integrator for an illumination system for illuminating an illumination field having an arcuate shape, the optical integrator comprising a first reflective element group having an array of first optical elements each having an arcuate profile corresponding to the arcuate shape of the illumination field, and each having a reflecting surface.

7. An optical integrator according to claim 6, wherein said array of first optical elements has a roughly circular outline.

8. An optical integrator according to claim 6, wherein said reflecting surface comprises an off-axis section of a spherical reflecting surface.

9. An optical integrator according to claim 6, wherein said reflecting surface comprises an off-axis section of an aspherical reflecting surface.

10. An optical integrator according to claim 6, further comprising a second reflective element group having a plurality of second optical elements, each second optical element having a rectangular shape and a predetermined second reflecting curved surface, said first and second reflecting element groups being opposingly arranged such that said first reflecting group is capable of forming, from a light beam incident thereon, a plurality of light source images at said plurality of second optical elements.

11. An optical integrator according to claim 10, wherein each second reflecting curved surface comprises an on-axis section of a spherical reflecting surface.

12. An optical integrator according to claim 10, wherein said first optical elements are arranged in a plurality of columns each with a corresponding axis passing therethrough, and wherein at least one of said plurality of first optical elements is rotatable about said corresponding axis so as to be capable of forming, from a light beam incident thereon, a plurality of light source images at one of said second optical elements.

13. An illumination system for illuminating a surface over an arcuate illumination field having an arcuate shape, comprising:

a) a light source for providing a light beam;

b) a first optical integrator comprising a first reflective element group having an array of first optical elements each having an arcuate profile corresponding to

the arcuate shape of the illumination field and a reflecting surface, said array of first optical elements designed so as to form a plurality of arcuate light beams capable of forming a plurality of light source images.

14. An illumination system according to claim 13, further comprising a condenser optical system designed so as to condense said plurality of arcuate light beams to illuminate the surface over the arcuate illumination field in an overlapping manner.

15. An illumination optical system according to claim 13, wherein said array of first optical elements has a roughly circular outline.

16. An illumination optical system according to claim 13, wherein said reflecting surface comprises an off-axis section of a spherical reflecting surface.

17. An illumination optical system according to claim 13, wherein said reflecting surface comprises an off-axis section of an aspherical reflecting surface.

18. An illumination system according to claim 13, further including a light beam converting unit removably arranged in said light beam between said light source and said first optical integrator.

19. An illumination system according to claim 14, wherein said condenser optical system comprises a condenser mirror with a focal point, said condenser mirror arranged such that said focal point substantially coincides with the surface.

20. An illumination system according to claim 14, wherein said first optical elements each have a focal length f_F , said condenser optical system has a focal length f_C, and wherein the condition

$$0.01 < |f_F/f_C| < 0.5$$

is satisfied.

21. An illumination optical system according to claim 13, further comprising a second reflective element group having a plurality of second optical elements, each second optical element having a rectangular shape and a predetermined second reflecting curved surface, said first and second reflecting element groups being opposingly arranged such that said plurality of light source images are formed at said plurality of second optical elements.

22. An optical integrator according to claim 21, wherein each second reflecting curved surface comprises an on-axis section of a spherical reflecting surface.

23. An illumination optical system according to claim 13 further including an auxiliary optical integrator arranged between said light source and said first optical integrator, said auxiliary optical integrator having a first auxiliary reflective element group comprising a first plurality of auxiliary optical elements, and an opposing second auxiliary reflective element group comprising a second plurality of auxiliary optical elements

24. An illumination optical system according to claim 23, wherein said first plurality of first auxiliary optical elements and said second plurality of second auxiliary optical elements are identical.

25. An illumination optical system according to claim 24, wherein each of said first and second auxiliary reflecting optical elements in said first and second plurality of first and second auxiliary reflecting optical elements are square.

26. An illumination optical system according to claim 23, further including a relay reflecting system arranged between said auxiliary optical integrator and said first optical integrator.

27. An illumination system according to claim 14, further including an illumination numerical aperture value capable of being varied by a variable aperture stop having a

variable diameter, said variable aperture stop arranged between said light source and said condenser optical system.

28. An illumination system according to claim 27, further comprising a first drive system operatively connected with said variable aperture stop and capable of changing said variable diameter.

29. An illumination system according to claim 13, further including a rotatable turret plate having a plurality of apertures capable of being inserted into said light beam.

30. An illumination system according to claim 29, further including a first drive system operatively connected to said turret plate and a control apparatus electrically connected to said drive system, said control apparatus being capable of controlling the rotation of said turret plate so as to insert one aperture of said plurality of apertures into said light beam.

31. An exposure apparatus for exposing the image of a mask having a predetermined pattern onto a photosensitive substrate comprising:

a) the illumination system according to claim 13;

b) a mask stage capable of supporting the mask;

c) a substrate stage capable of supporting the photosensitive substrate; and

d) a projection optical system, arranged between said mask stage and said substrate stage, designed so as to project the predetermined pattern of the mask onto the photosensitive substrate over an arcuate image field corresponding to said arcuate illumination field.

32. An exposure apparatus according to claim 31, further including a first drive system operatively connected to said mask stage, a second drive system operatively connected to said wafer stage, and a control system electrically connected to said first and second drive systems for controlling the synchronous driving of said mask stage and wafer stage relative to said projection optical system.

33. An exposure apparatus according to claim 31, wherein said illumination system includes a first variable aperture stop having a first variable diameter.

34. An exposure apparatus according to claim 33, wherein said projection optical system further includes a second variable aperture stop having a second variable diameter.

35. An exposure apparatus according to claim 34, further including first and second drive systems operatively connected to said first and second variable aperture stops, and a control apparatus electrically connected to said first and second drive units so as to control the coherence factor by varying said first and second variable aperture diameters.

36. An exposure apparatus according to claim 35, further comprising an adjustable light beam converting unit removably arranged in said light beam between said light source and said optical integrator.

37. An exposure apparatus according to claim 35, further including a third drive system operatively connected to said light beam converting unit and electrically connected to said control apparatus so as to cooperatively adjust in concert with said first and second drive systems, said light beam converting unit, said first variable aperture and said second variable aperture.

38. A method exposing a pattern of a mask onto a photosensitive substrate with an arcuately shaped illumination field, the method comprising the steps of:

a) providing an illumination light beam;

b) reflectively dividing said illumination light beam into a plurality of arcuate light beams corresponding to the arcuately shaped exposure field; and

c) condensing said arcuate light beams onto the object over the arcuately shaped exposure field.

39. A method according to claim 38, further including the steps, in said step b), of:

i) reflecting said light beam from a first array of reflecting elements each having an arcuate shape and a reflecting surface having an eccentric curvature, and forming a plurality of light source images.

40. A method according to claim 39, further including the step, after said step i), of:

ii) reflecting light from said plurality of light source images with a second array of reflecting elements opposingly arranged relative to said first array of reflecting elements.

41. A method of patterning the surface of a photosensitive substrate with a pattern on a mask in the manufacturing of a semiconductor device, the method comprising the steps of:

a) providing an illumination light beam;

b) reflectively dividing said illumination light beam into a plurality of arcuate light beams corresponding to an arcuately shaped illumination field;

c) condensing said arcuate light beams onto the mask over the arcuately illumination field; and

d) projecting light from the mask onto the photosensitive substrate.

42. A method according to claim 41, wherein said step b) includes the steps of:

i) reflecting said light beam from a first array of reflecting elements each having an arcuate shape and a reflecting surface having an eccentric curvature, and forming a plurality of light source images; and

ii) reflecting light from said plurality of light source images with a second array of reflecting elements opposingly arranged relative to said first array of reflecting elements.

43. An exposure apparatus for exposing a photosensitive substrate with a mask having a pattern comprising:

a) an illumination system for illuminating the mask with an arcuate illumination field, said illumination system comprising:

i) a light source capable of supplying a light beam with a wavelength $\lambda < 200$nm;

ii) an optical integrator for splitting said light beam into a plurality of light beams and comprising a plurality of reflecting elements; and

iii) a condenser optical system capable of condensing said plurality of light beams so as to form said arcuate illumination field, said condenser optical system having a reflecting element with a second optical axis intersecting a first optical axis; and

b) a projection optical system disposed in an optical path between the mask and the photosensitive substrate so as to form an image of the mask pattern on the photosensitive substrate, said projection optical system comprising said first optical axis and a plurality of reflecting elements arranged relative thereto.

44. An exposure apparatus according to claim 43, wherein said projection optical system includes a pupil with a light intensity distribution thereat, the exposure apparatus further comprising an illumination changing system capable of changing said light intensity distribution at said pupil.

45. A method of exposing a photosensitive substrate, comprising the steps of:

a) providing the exposure apparatus according to claim 43;

b) illuminating the mask with said arcuate illumination field using said illumination system; and

c) projecting an image of the mask pattern onto the photosensitive substrate using said projection optical system.

46. A method of exposing a photosensitive substrate with a mask having a pattern, comprising the steps of:

a) providing the exposure apparatus according to claim 44;

b) changing said light intensity distribution at said pupil using said illumination changing system;

c) illuminating the mask with said arcuate illumination field using said illumination system; and

d) projecting an image of the mask pattern onto the photosensitive substrate using said projection optical system.

47. An exposure apparatus for exposing a photosensitive substrate with a mask having a pattern comprising:

a) an illumination system for illuminating the mask with an arcuate illumination field, said illumination system comprising i) a light source capable of supplying a light beam of wavelength $\lambda < 200$nm, and ii) a plurality of reflecting members designed so as to direct said light beam to form said arcuate illumination field on the mask;

b) a projection optical system disposed in an optical path between the mask and the photosensitive substrate so as to form an image of said predetermined pattern on the photosensitive substrate, said projection system comprising a plurality of reflecting members and having a pupil with a light intensity distribution thereat; and

c) an illumination changing system for changing said light intensity distribution at said pupil.

48. An exposure apparatus according to claim 47, wherein said illumination system further includes an optical integrator having a plurality of reflecting elements.

49. A method of exposing a photosensitive substrate with a mask having a pattern comprising the steps of:

a) providing an exposure apparatus comprising:

i) an illumination system for illuminating the mask with an arcuate illumination field, said illumination system comprising a light source capable of supplying a light beam of wavelength $\lambda < 200$nm, and a plurality of reflecting members designed so as to direct said light beam to said arcuate illumination field on the mask;

ii) a projection optical system disposed in an optical path between the mask and the photosensitive substrate so as to form an image of the pattern on the photosensitive substrate, said projection system comprising a plurality of reflecting members and having a pupil with a light intensity distribution thereat; and

iii) an illumination changing system capable of changing said light intensity distribution at said pupil;

b) changing said light intensity distribution at a pupil of said projection system using said illumination changing system;

c) illuminating the mask with said arcuate illumination field using said illumination system; and

d) projecting an image of the mask pattern onto the photosensitive substrate using said projection optical system.

50. A method according to claim 49, wherein one of said plurality of reflecting members is an optical integrator having a plurality of reflecting elements.

51. An exposure apparatus for exposing with a light intensity distribution a photosensitive substrate with a mask having a pattern, comprising:

a) an illumination system for illuminating the mask with an arcuate illumination field, said illumination system comprising i) a light source capable of supplying a light beam of wavelength $\lambda < 200$nm, and ii) a plurality of

reflecting members designed so as to direct said light beam to said arcuate illumination field on the mask; and

b) a projection optical system disposed in an optical path between the mask and the photosensitive substrate so as to form an image of the pattern on the photosensitive substrate, said projection system comprising a plurality of reflecting members; and

c) wherein at least one reflecting member in said plurality of reflecting members is adjustable so as to adjust the light intensity distribution at the photosensitive substrate.

52. An exposure apparatus according to claim 51, wherein one of said plurality of reflecting members is an optical integrator having a plurality of reflecting elements.

53. A method of exposing with a light intensity distribution a photosensitive substrate with a mask having a pattern, the method comprising the steps of:

a) providing an exposure apparatus comprising:

i) an illumination system for illuminating the mask with an arcuate illumination field, said illumination system comprising a light source capable of supplying a light beam of wavelength $\lambda < 200$nm, and a plurality of reflecting members designed so as to direct said light beam to said arcuate illumination field on the mask, at least one of said plurality of reflecting members being adjustable so as to adjust said light intensity distribution at the photosensitive substrate;

ii) a projection optical system disposed in an optical path between the mask and the photosensitive substrate so as to form an image of the predetermined pattern on the photosensitive substrate, said projection system comprising a plurality of reflecting members;

b) adjusting the light intensity distribution at the photosensitive substrate using said at least one of said plurality of reflecting members;

c) illuminating the mask with said arcuate illumination field using said illumination system; and

d) projecting an image of the pattern onto the photosensitive substrate using said projection system.

54. A method according to claim 51, wherein one of said plurality of reflecting members is an optical integrator having a plurality of reflecting elements.

55. A method of exposing with a light intensity distribution a photosensitive substrate with a mask having a pattern, the method comprising the steps of:

a) providing an exposure apparatus comprising:

i) an illumination system for illuminating the mask with an arcuate illumination field, said illumination system comprising a light source system capable of supplying a light beam of wavelength $\lambda < 200$nm, and a plurality of reflecting members designed so as to direct said light beam to said arcuate illumination field on the mask;

ii) a projection system having a pupil and disposed in an optical path between the mask and the photosensitive substrate so as to form an image of the pattern on the photosensitive substrate, said projection system comprising a plurality of reflecting members;

b) changing the light intensity distribution at said pupil;

c) adjusting the light intensity distribution at the photosensitive substrate;

d) illuminating the mask with said arcuate illumination field using said illumination system; and

e) projecting an image of the mask pattern onto the photosensitive substrate using said projection system.